Simulation Based Acquisition: Concepts and Trends

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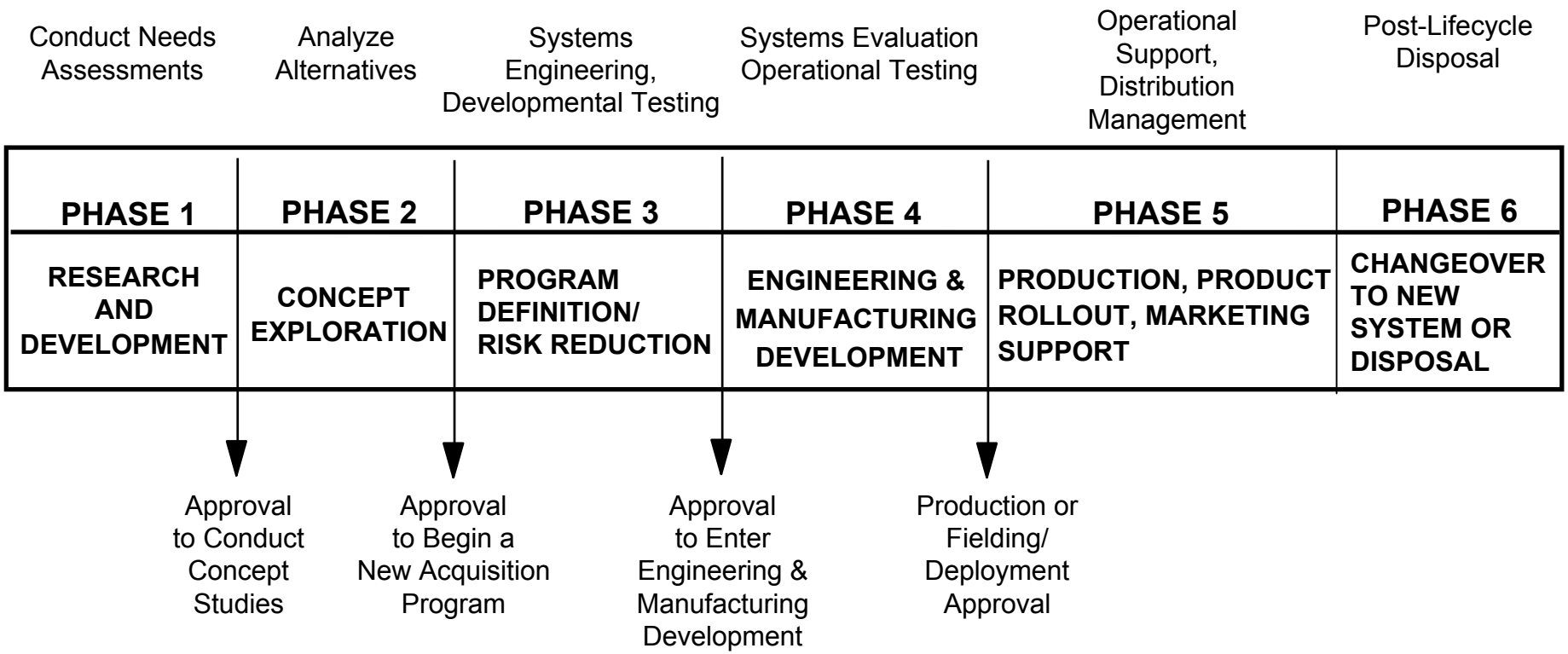
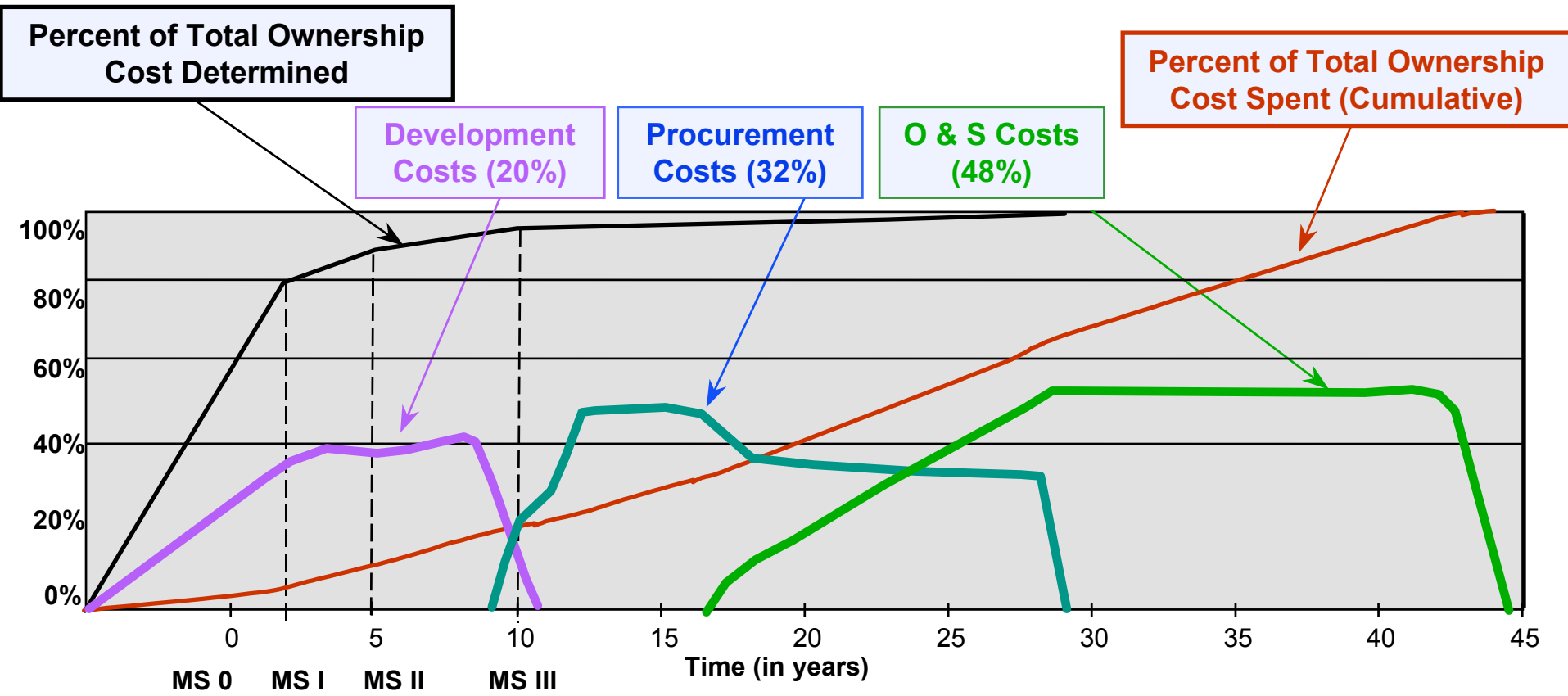
Acquisition Life Cycle (Traditional View)



Problems with the Use of M&S in Acquisition

- Little sharing of models and simulations within or between programs
- Significant gaps in needed standards
- VV&A practices/procedures are frequently inadequate, leading to credibility problems
- Models and simulations tend not to interoperate across functional boundaries, hindering ability of IPTs to collaborate

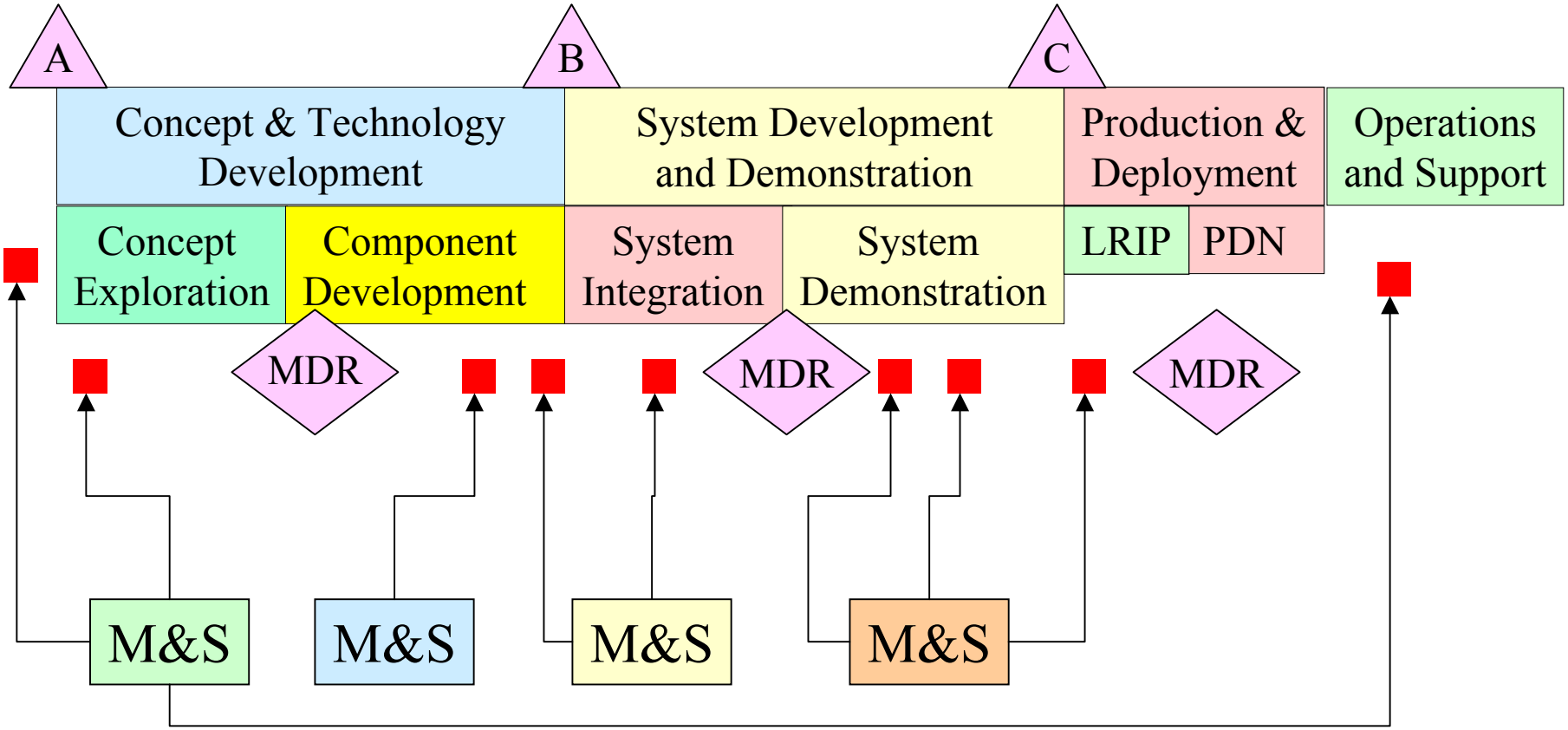
DoD Cost-Based Motivation for Simulation Based Acquisition



Efficient Exploration of the Design Space Early in the Program Is Key to Reducing Total Ownership Cost

Source: *The Simulation Based Acquisition Vision: A Brief Tutorial*, Nicholas E. Karangelen, March 1998

Acquisition Life Cycle (Per DoD Instruction 5000.2)



Reference: Joe R. East
What SMART Means for Acquisition
2001 SMART Conference

Introduction of SBA To DoD Policy

- **DoD Directive 5000.1 w/Chg1, 4 January 2001**

- **4.5.4 Simulation-Based Acquisition. Program managers shall plan and budget for effective use of modeling and simulation to reduce the time, resources, and risk associated with the entire acquisition process...**

DoD Instruction 5000.2 w/ Chg1, 4 January 2001

4.7.3.2.1.1.... Discovery and development are aided by the use of simulation-based acquisition and test and evaluation and guided by a system acquisition strategy and test and evaluation master plan...

DoD 5000.2 Regulation, 4 January 2001 "Final" DRAFT

5.2.2.4 Simulation Based Acquisition (SBA)
Whenever and wherever possible throughout systems acquisition, the PM shall make effective use of M&S approaches to provide a robust analysis of system performance. . . . .

What is Simulation Based Acquisition?

A robust M&S engineering environment --

- Starts early, from initial requirement & concept
- Intensive “wringing-out” in synthetic, collaborative environment of cost, function, performance across system life cycle
- Reuse of M&S across system life cycle, across programs/services

A revised DoD acquisition process --

- Integrates functional areas using collaborative environment
- Rapid, multiple assessments of trade space prior to locking requirements
- Thorough and early understanding of the implications of performance requirements & design to total ownership cost.

A cultural change --

- New educational curriculum
- Empowered collaborating teams, including industry partners
- Up-front emphasis on and investment in M&S
- Increasing reliance on M&S to reduce design risk

Reference: Randy Zittel
SMART and DoD Acquisition Issues
2001 SMART Conference

SBA Principles

- Advanced information technology applications.
- Comprehensive functional assessments, i.e. design, support, manufacturing, achieving reduced risk and more informed decisions
- Early optimization of system performance vs. total ownership cost.
- Enduring collaborative environments with reusable, interoperable tools and supporting resources
- Automated near-real-time sharing of relevant information among all personnel thru a common technical architecture; and open, commercial, data interchange standards.

Reference: Randy Zittel
SMART and DoD Acquisition Issues
2001 SMART Conference

Some Early Examples of SBA Applications

- Boeing 777 aircraft
  - First large-scale corporate investment in integrated Computer-Aided Design (CAD)
  - Most often cited example
  - Aircraft performance simulations still done offline
- Daimler-Chrysler automobiles
  - Viper, others
  - Cited in Daimler-Chrysler television advertisements in 1999-2000
- Semiconductor design, fabrication, and assembly
- Defense Advanced Research Projects Agency (DARPA) Simulation-Based Design program (late 1990s)

SBA Historical Background

1994	Final Report of the Acquisition Task Force on Modeling and Simulation (DDR&E)
	Naval Research Advisory Committee Report on Modeling and Simulation (NRAC/ASN(RDA))
1995	Collaborative Virtual Prototyping: An Assessment for the Common Support Aircraft Initiative (NAVAIR)
1996	Collaborative Virtual Prototyping Sector Study (North American Technology and Industrial Base Organization)
	Study on the Application of Modeling and Simulation to the Acquisition of Major Weapon Systems (American Defense Preparedness Association (ADPA)
	Study on the Effectiveness of Modeling and Simulation in the Weapon System Acquisition Process (DoD Director, Test, Systems Engineering and Evaluation)
1997	Technology for the United States Navy and Marine Corps, 2000-2035, Becoming a 21st Century Force, Volume 9: Modeling and Simulation (Naval Studies Board, National Research Council (NRC))
1998	A Roadmap for Simulation Based Acquisition – Report of the Joint Simulation Based Acquisition Task Force, December 4, 1998 (http://www.msosa.dmso.mil/sba/documents.asp)
1998	Simulation Based Acquisition: A New Approach – Report of the Military Research Fellows, Defense Systems Management College, 1997-1998. (www.msosa.dmso.mil/sba/documents.asp).
1999	Advanced Engineering Environments: Achieving the Vision, Phase 1 (NRC – prepared for NASA)
2000	SIMTECH 2007 Mini-Symposium and Workshop Proceedings: Session 1, December 1997, and Session 2, August 1998 (Military Operations Research Society (MORS))
2001	NRC Committee on Modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition (report to be published in late 2001; prepared for Defense Modeling and Simulation Office(DMSO))

Joint DoD Navy-oriented Industry-driven Private organization

Key Architectural Constructs from the SBA Roadmap

- Collaborative Environment (CE)

  "Within the context of SBA, a collaborative environment (CE) is an enduring collection of subject matter experts (SMEs) supported by interoperable tools and data bases, authoritative information resources, and product/process models that are focused on a common domain or set of problems."

- Distributed Product Description (DPD)

  "A Distributed Product Description (DPD) is a distributed collection of product-centric information that is interconnected via web technology into what appears (to the user) to be a single, logically unified product representation."

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Elements of a Collaborative Environment (CE)

- A defined purpose for which the CE is intended to be used — *Purpose*
- The involvement of subject matter experts (SMEs) from all functional disciplines that are stakeholders in the domain or set of problems upon which the CE is focused — *People*
- Availability of a set of interoperable models, simulations, tools, and data appropriate to the domain or problem set — *Tools*
- Systems to enable electronic collaboration over a distance for exchange of information, access to authoritative data, and execution of simulations
- A systems architecture framework for the CE, derived from a common reference — *Standards*
- An agreed upon set of standards, rules, and local conventions, to which all CE users and components adhere
- An agreed upon set of processes for configuration management and for Verification, Validation, and Accreditation (VV&A) — *Processes*
- Coordinated policy, planning, and investment strategies to ensure continuing support of the CE

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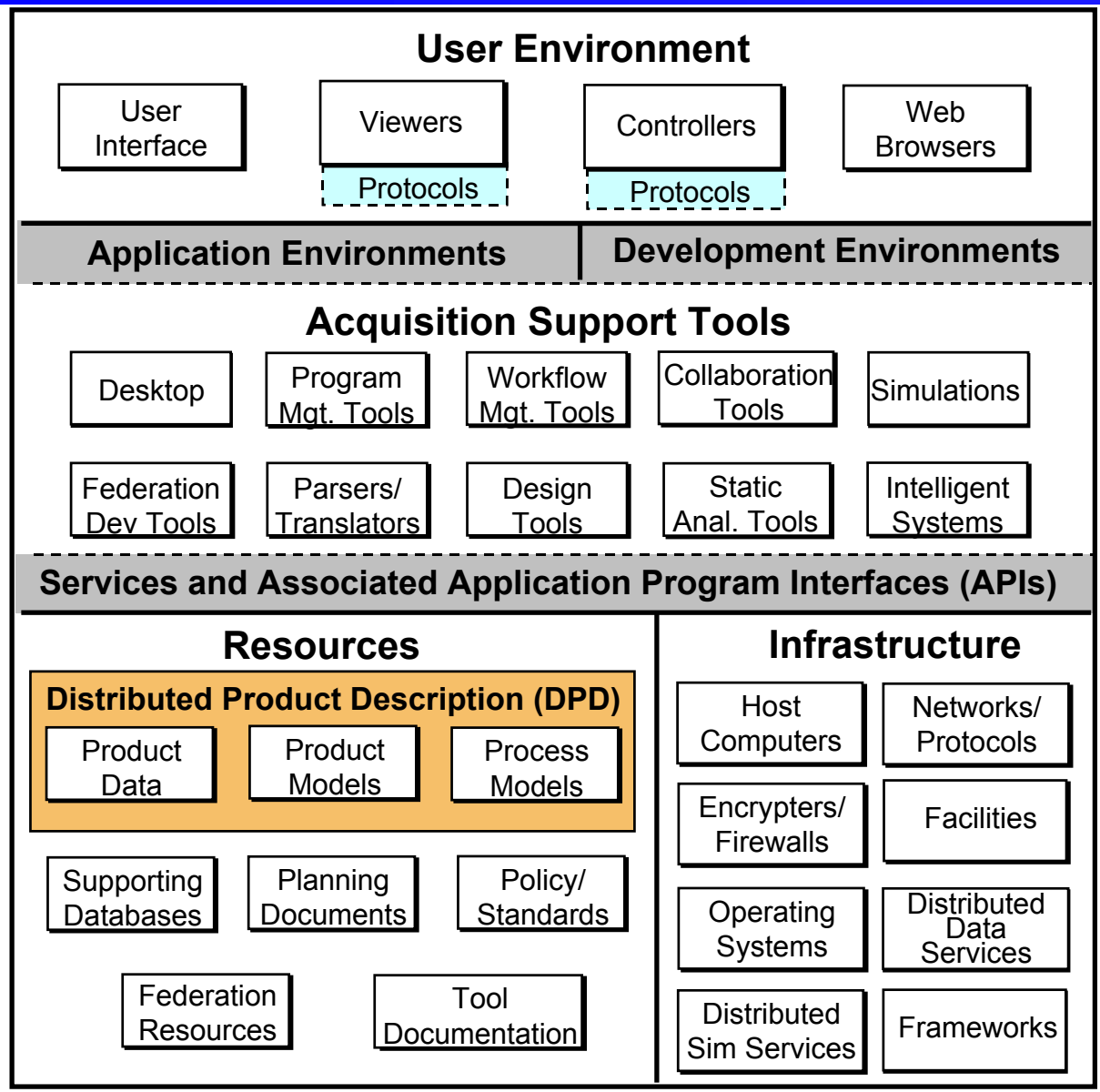
Collaborative Environment Reference Systems Architecture (CERSA)

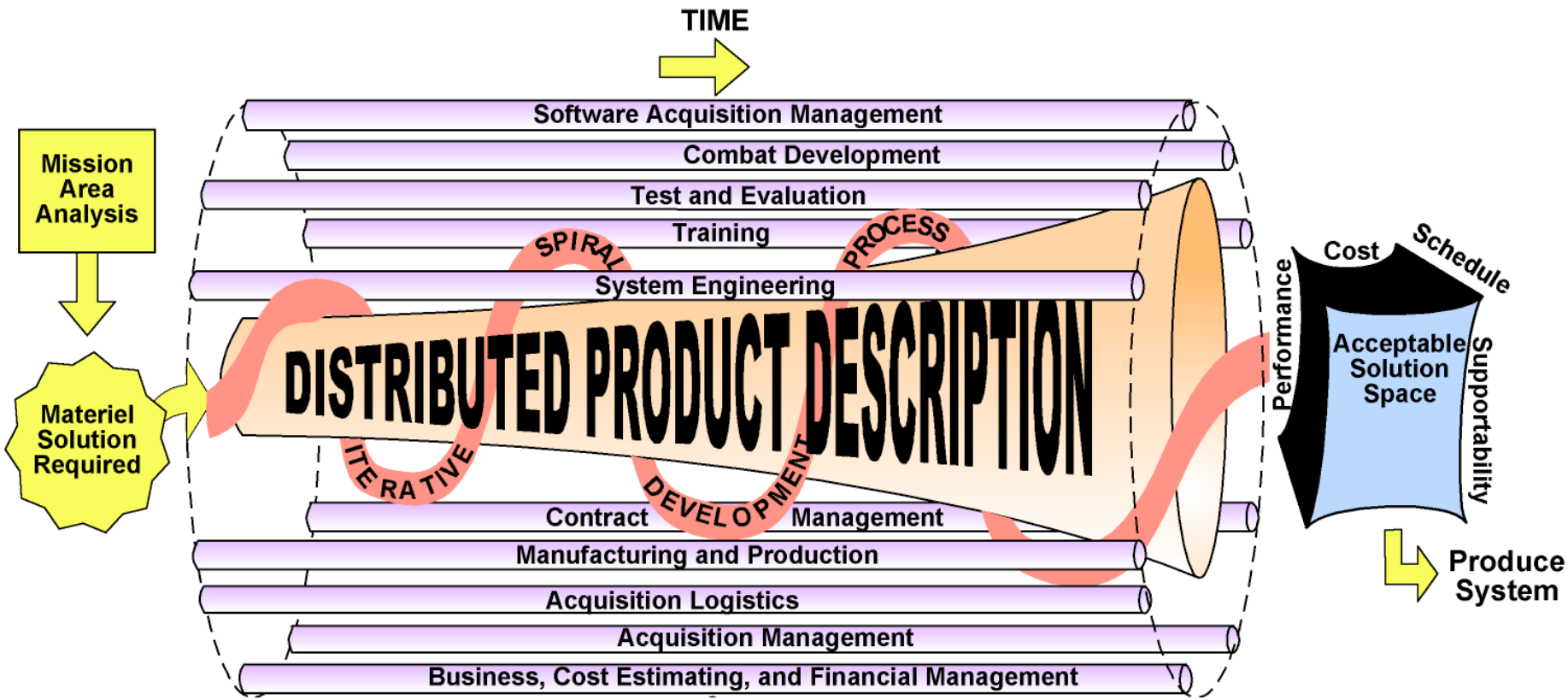


Distributed Product Descriptions (DPDs)

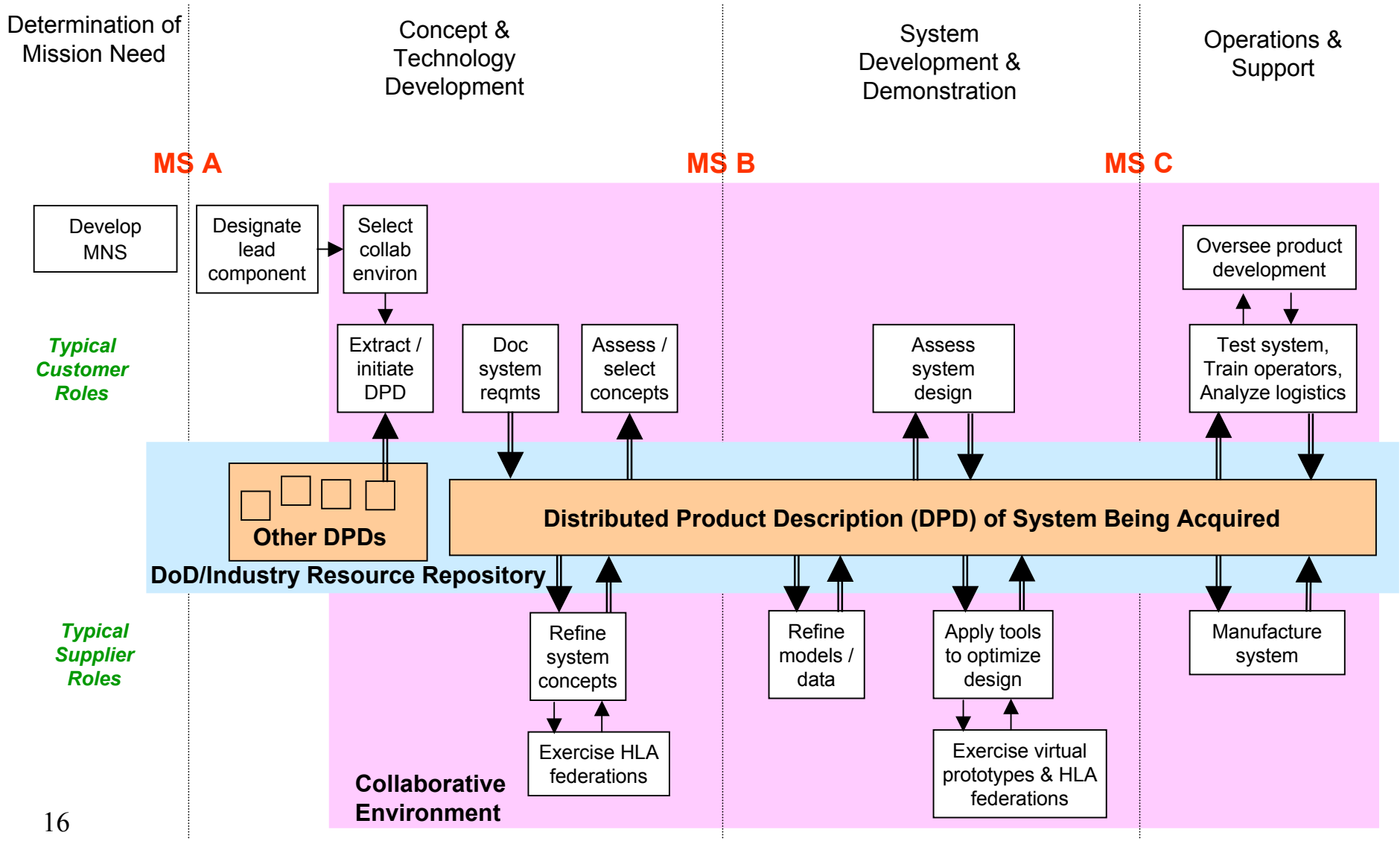
- Distributed collection of digital product information
- Provides view of current product state to all program participants throughout all program phases
- Composed of ...
  - Product data
  - Product models
  - Process models
  - Other (reference materials, metadata fields, …)

Source: SBA Road Map

Operational Architecture – Evolution of a DPD During System Acquisition



Operational Architecture – DPD ConOps Overlaid on DoD Acquisition Process



Desired Features for Repositories to Support SBA

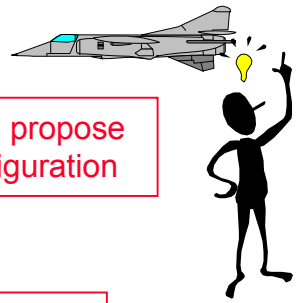
- Version management and archival capabilities for product data
- Data schema – consistent semantic representations for data elements used by models, simulations, and other tools
- Metadata – for sources of authority, VV&A information, etc.
- Data interchange formats (DIFs) – standard syntax for exchanged data
- Consistency checking – documented relationships among related elements; automatic calculations where possible
- Electronic linkages – to other individual and consolidated sources of authoritative information, wherever possible
- Automatic change notification – via electronic mail to registered users of specific information
- Subscription service – pre-defined sets of information for individual users / individual models/simulations/tools

Example of Use of SBA Concepts in Systems Engineering Activities

- Engineering, Manufacturing, and Development (EMD) phase of fighter aircraft program
- Product development collaborative environment with design engineers, manufacturing engineers, cost analysts, logisticians, etc.
- Consider the change notification, assessment, and acceptance process
- View from the perspective of an aerodynamics engineer:
  - Has access and change authority to all aerodynamic data and models in the DPD
  - Has access to
    - Structural data
    - Propulsion data
    - Thermal data
    - Guidance and Control data
  - Cannot access cost information

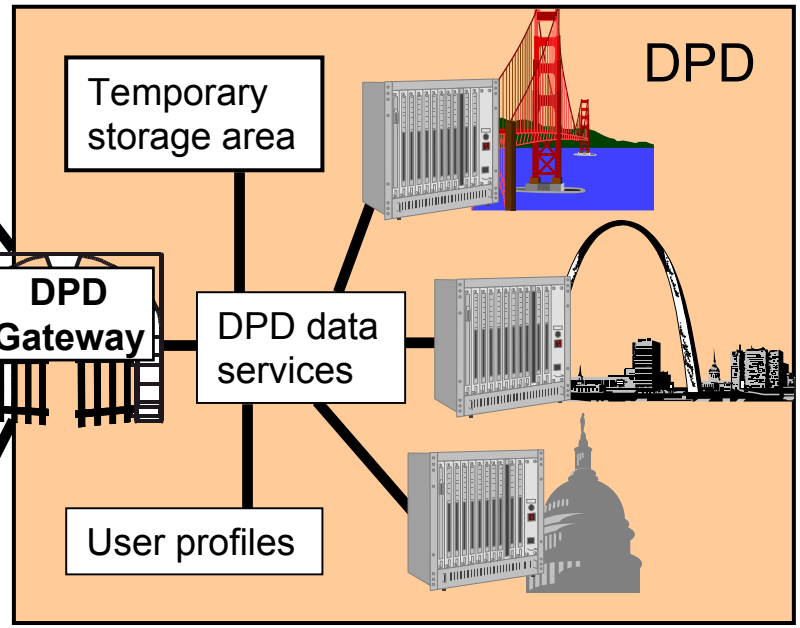
Example of Use of SBA Concepts in Systems Engineering

Change Notification Process



1. Structural engineers propose change to product configuration

2. Temporary configuration and alerts generated



5. Aero engineer receives logon screen and is informed of new alert on structural change

Aero directory
- Atmos model
- Wing aero data
- etc.

Links (read only)
- G&C algorithm
- Propulsion data
- etc.

Active Alerts
- Structural change
  - description
  - affects
    - **Aero**
    - Structural
    - Thermal
    - G&C
    - Manufacturing
    - Logistics
    - Cost

3. Aerodynamics engineer logs on

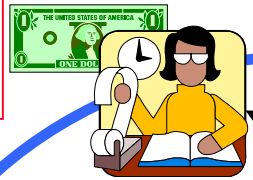
4. Using aero engineer's user profile, DPD data services collect and format aero data & models and alerts

Example of Use of SBA Concepts in Systems Engineering

Change Assessment Process

5. Cost analysts determine life cycle costs of process changes

1. Aero engineer downloads proposed structural changes via DIFs



Cost

DIFs

Temporary storage area

DPD

Manufacturing

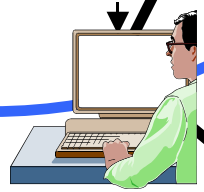
DPD Gateway

DPD data services

Logistics

User profiles

3. Manufacturing & logistics report possible cost impact for modified production and maintenance processes – they define and incorporate modified processes into temporary area of DPD



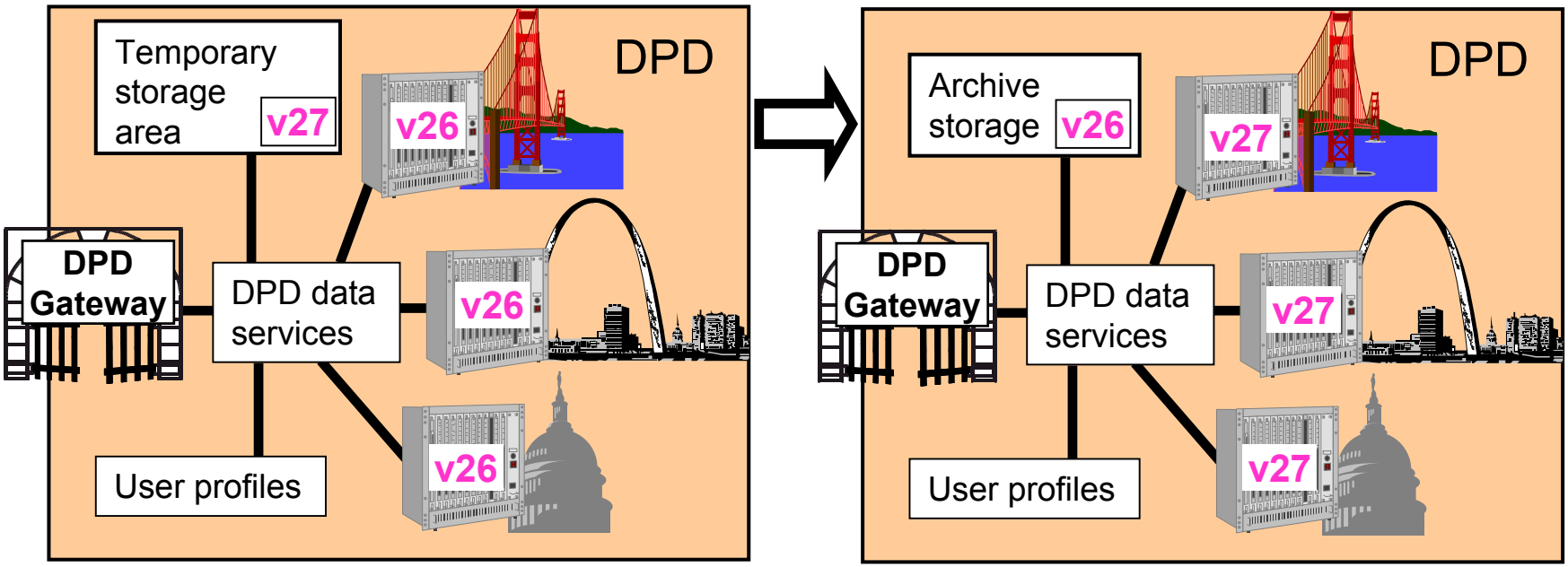
DPD Admin

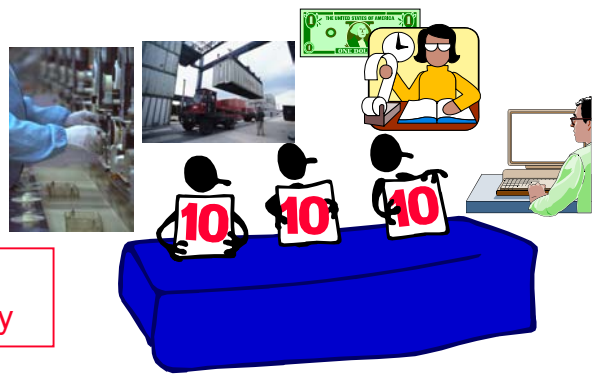
2. Aero engineer exercises aero models & simulations – positive benefits; no negatives

4. Aero engineer requests access to logistics & manufacturing information – granted by DPD administrator

Example of Use of SBA Concepts in Systems Engineering

Change Acceptance Process





1. All users accept change electronically

2. DPD Data Services:
- Archives old DPD version
- Creates new version number
- Transfers proposed mods into new current version
- updates user profiles
- Frees temporary storage area

So, Where is SBA Today?

- Several DoD acquisition programs now experimenting with SBA concepts
- US Air Force now requires development of DPDs in its acquisition instruction 16-1002 (June, 2000)
- US Army SMART initiative has also adopted these concepts
- The JSF program's Modeling and Simulation Support Plan (MSSP) specifies use of the JSF Strike Warfare Collaborative Environment (SWCE) and development of the JSF DPD in the next phase of acquisition

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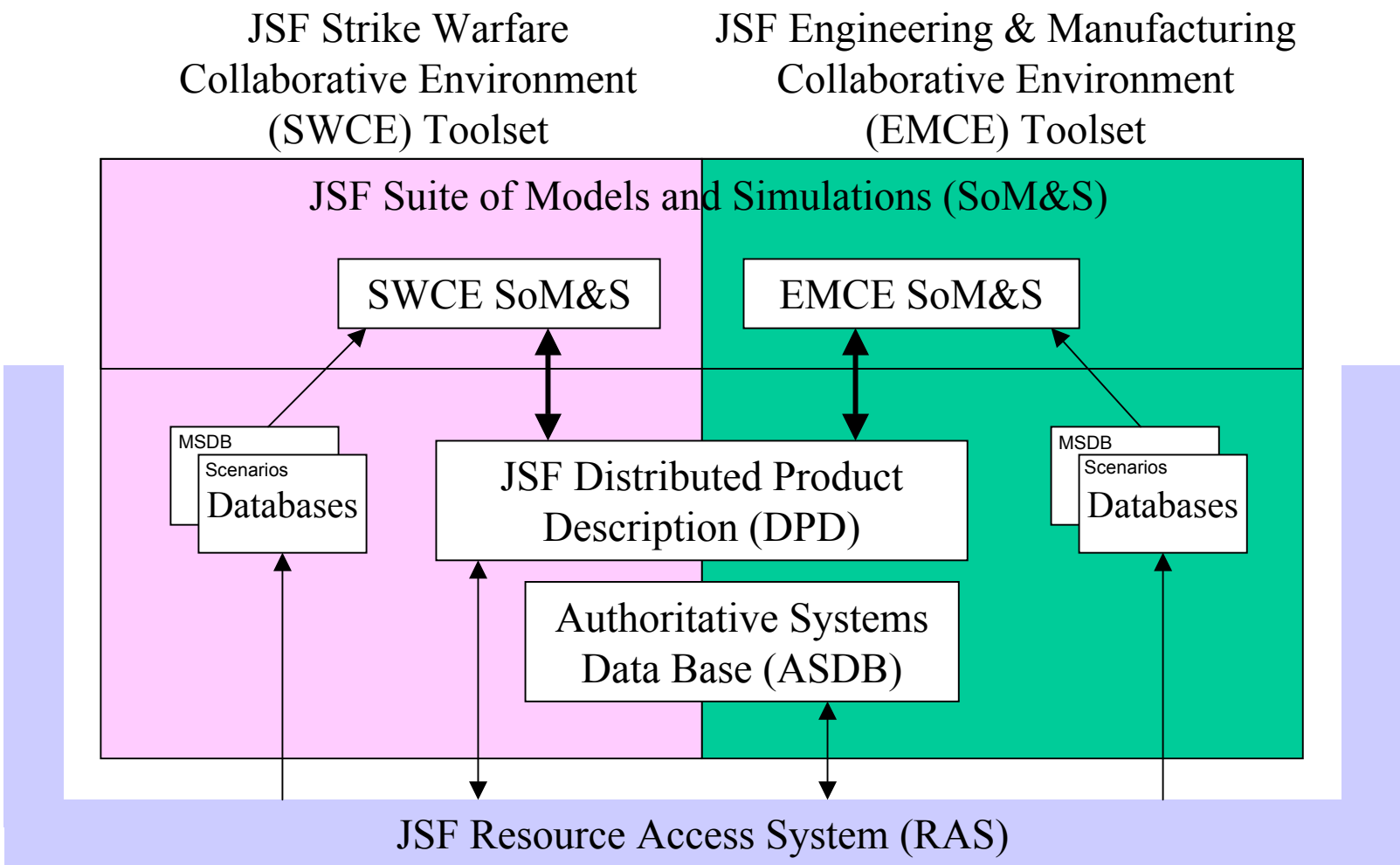
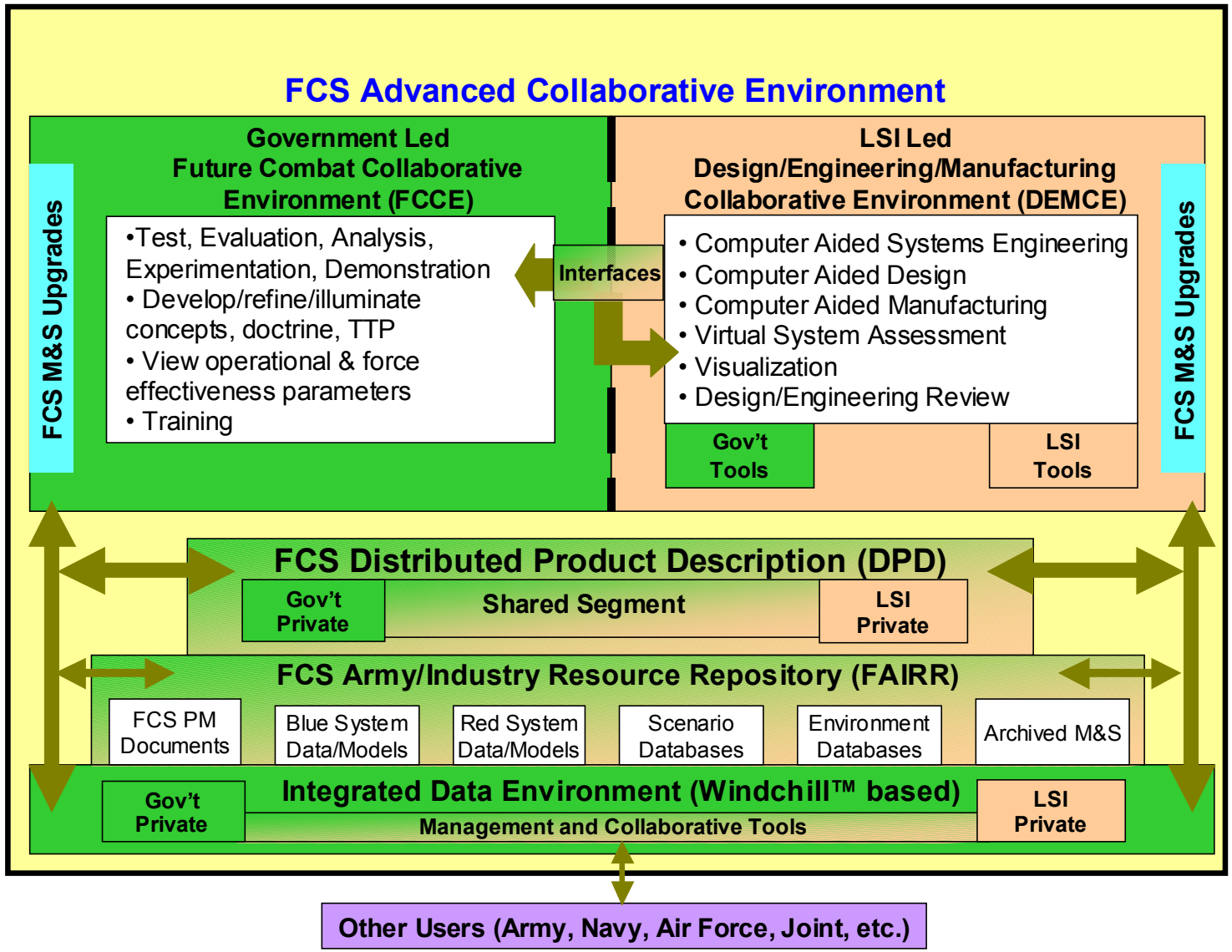
Joint Strike Fighter (JSF) Collaborative Environment Architecture



Source: "The Joint Strike Fighter (JSF) Strike Warfare Collaborative Environment (SWCE)," in *Proc., 2000 Fall Simulation Interoperability Workshop*, Simulation Interoperability Standards Organization, September 17-22, 2000, Orlando, FL.

FCS Advanced Collaborative Environment Top-Level Concept



Summary

- SBA concepts are being advanced in Industry and in the Department of Defense (DoD) as mechanisms for making products “better, faster, and cheaper”
- Each company and each DoD organization seem currently to be making choices in pursuing SBA that are believed to provide advantage to their own pursuits, while trying to minimize infrastructure costs
  - Cross-organization and cross-DoD-program efforts seem to be receiving little attention at the required levels for substantial progress to be made
  - Little attention is being focused on “common good” activities
- Standards efforts are progressing, but slowly
- At a technical level, SBA concepts “are going to come” (whether organized or in an ad hoc fashion)
- SBA concepts, when implemented, have the potential to significantly aid in a robust multi-discipline, iterative systems engineering/acquisition process
- For more information, go to http://www.msiac.dmso.mil/sba